

CLAIMS

What is claimed is:

1. In a wireless communication system, a method of performing channel estimation, the method comprising:

- (a) receiving reference signals having different lengths;
- (b) processing the reference signals using a fast Fourier transform (FFT); and
- (c) extending the FFT to a desired length L for more efficient computation.

2. The method of claim 1 wherein the FFT is extended to the length L to process a plurality of different burst types associated with the reference signals.

3. In a wireless communication system, a method of performing channel estimation, the method comprising:

- (a) receiving a time domain signal \underline{r} ;
- (b) multiplying, element-to-element, the sequences \underline{m} and \underline{r} by a chirp waveform, the chirp waveform being based on the length of the FFT and denoting the resulting sequences as \underline{m}_w and \underline{r}_w respectively, where \underline{m} is a midamble sequence; and
- (c) creating a chirp sequence \underline{v} based on the chirp waveform.

4. The method of claim 3 wherein the chirp waveform is $W^{n/2}$ for $n=0,1,2,\dots,P-1$ where $P = 456$ for burst types 1/3 or $P = 192$ for burst type 2, and

$$W = e^{-j\frac{2\pi}{P}}$$

5. The method of claim 4 wherein the chirp sequence $\underline{v} = W^{-(n-P+1)^2/2}$ for $n=0,1,2,\dots,2P-2$.

6. A wireless communication system for performing channel estimation, the system comprising:

- (a) means for receiving reference signals having different lengths;
- (b) means for processing the reference signals using a fast Fourier transform (FFT); and

(c) means for extending the FFT to a desired length L for more efficient computation.

7. The system of claim 6 wherein the FFT is extended to the length L to process a plurality of different burst types associated with the reference signals.

8. A wireless communication system for performing channel estimation, the system comprising:

- (a) means for receiving a time domain signal \underline{r} ;
- (b) means for multiplying, element-to-element, the sequences \underline{m} and \underline{r} by a chirp waveform, the chirp waveform being based on the length of the FFT and denoting the resulting sequences as \underline{m}_w and \underline{r}_w respectively, where \underline{m} is a midamble sequence; and

(c) means for creating a chirp sequence \underline{v} based on the chirp waveform.

9. The system of claim 8 wherein the chirp waveform is $W^{n/2}$ for $n=0,1,2,\dots,P-1$ where $P = 456$ for burst types 1/3 or $P = 192$ for burst type 2, and

$$W = e^{-j\frac{2\pi}{P}}.$$

10. The system of claim 9 wherein the chirp sequence $\underline{v} = W^{-(n-P+1)^2/2}$ for $n=0,1,2,\dots,2P-2$.

11. A wireless transmit/receive unit (WTRU) for performing channel estimation, the WTRU comprising:

- (a) means for receiving reference signals having different lengths;
- (b) means for processing the reference signals using a fast Fourier transform (FFT); and
- (c) means for extending the FFT to a desired length L for more efficient computation.

12. The WTRU of claim 11 wherein the FFT is extended to the length L to process a plurality of different burst types associated with the reference signals.

13. A wireless transmit/receive unit (WTRU) for performing channel estimation, the WTRU comprising:

- (a) means for receiving a time domain signal \underline{r} ;
- (b) means for multiplying element-to-element the sequences \underline{m} and \underline{r} by a chirp waveform, the chirp waveform being based on the length of the FFT and denoting the resulting sequences as \underline{m}_w and \underline{r}_w respectively, where \underline{m} is a midamble sequence; and
- (c) means for creating a chirp sequence \underline{v} based on the chirp waveform.

14. The WTRU of claim 13 wherein the chirp waveform is $W^{n/2}$ for $n=0,1,2,\dots,P-1$ where $P = 456$ for burst types 1/3 or $P = 192$ for burst type 2, and

$$W = e^{-j\frac{2\pi}{P}}$$

15. The WTRU of claim 14 wherein the chirp sequence $\underline{v} = W^{-(n-P+1)^2/2}$ for $n=0,1,2,\dots,2P-2$.

16. A base station (BS) for performing channel estimation, the BS comprising:
 - (a) means for receiving reference signals having different lengths;
 - (b) means for processing the reference signals using a fast Fourier transform (FFT); and
 - (c) means for extending the FFT to a desired length L for more efficient computation.

17. The BS of claim 16 wherein the FFT is extended to the length L to process a plurality of different burst types associated with the reference signals.

18. A base station (BS) for performing channel estimation, the BS comprising:
 - (a) means for receiving a time domain signal \underline{r} ;
 - (b) means for multiplying element-to-element the sequences \underline{m} and \underline{r} by a chirp waveform, the chirp waveform being based on the length of the FFT and denoting the resulting sequences as \underline{m}_w and \underline{r}_w respectively, where \underline{m} is a midamble sequence; and
 - (c) means for creating a chirp sequence \underline{v} based on the chirp waveform.

19. The BS of claim 18 wherein the chirp waveform is $W^{n^2/2}$ for $n = 0, 1, 2, \dots, P-1$ where

$$P = 456 \text{ for burst types 1/3 or } P = 192 \text{ for burst type 2, and } W = e^{-j\frac{2\pi}{P}}.$$

20. The BS of claim 19 wherein the chirp sequence $\underline{v} = W^{-(n-p+1)^2/2}$ for $n = 0, 1, 2, \dots, 2P-2$.

21. In a wireless communication system, a method for performing channel estimation, the method comprising:

- (a) receiving a time domain signal \underline{r} ;
- (b) expressing $\underline{r} = \underline{m} \otimes \underline{h}$ in the frequency domain, resulting in an output signal $\underline{R} = \underline{M} \cdot \underline{H}$, where \underline{m} is a midamble sequence, \underline{h} is a channel impulse response, \otimes is a circular convolution operator, \underline{R} is the fast Fourier transform (FFT) of time domain signal \underline{r} , \underline{M} is the FFT of midamble sequence \underline{m} , and \underline{H} is the FFT of channel impulse response \underline{h} , and $\underline{R} = F(\underline{r})$, $\underline{M} = F(\underline{m})$ and $\underline{H} = F(\underline{h})$ where $F()$ is defined as the operator of forward or inverse FFT;
- (c) calculating \underline{H} is calculated by dividing \underline{R} by \underline{M} , where $\underline{R}/\underline{M}$ is the element-to-element division of the corresponding two FFT sequences; and
- (d) estimating the impulse response by inverse FFT of \underline{H} by calculating $\underline{h} = F^{-1}(\underline{H})$ where $F^{-1}()$ is defined as the operator of forward or inverse FFT and $\underline{h} = F^{-1}(F(\underline{r})/F(\underline{m}))$ and $F(\underline{r})/F(\underline{m})$ denotes the element-to-element division of FFT sequences $F(\underline{r})$ and $F(\underline{m})$.

22. The method of claim 21 wherein the forward or inverse FFT are exchangeable in the following form: $F^{-1}(\underline{x}) = \frac{1}{P} (F(\underline{x}^*))^*$, wherein P is the length of FFT.

23. The method of claim 22 wherein the FFT sequences $F(\underline{r})$ and $F(\underline{m})$ are calculated by extended FFT and divided element-to-element, the method further comprising:

- (e) multiplying, element-to-element, the sequences \underline{m} and \underline{r} by a chirp waveform and denoting the resulting sequences as \underline{m}_w and \underline{r}_w respectively;
- (f) creating a chirp sequence based on the chirp waveform;

(g) zero padding the sequences \underline{m}_w , \underline{r}_w and \underline{v}_z in the tail until the length of the sequences achieves L, and denoting the resulting sequences as $\underline{m}_{w,z}$, $\underline{r}_{w,z}$ and \underline{v}_z ;

(h) performing an L-point FFT on $\underline{m}_{w,z}$, $\underline{r}_{w,z}$ and \underline{v}_z each such that $F(\underline{m}_{w,z})$, $F(\underline{r}_{w,z})$ and $F(\underline{v}_z)$;

(i) multiplying, element-to-element, the FFT of $\underline{m}_{w,z}$ and $\underline{r}_{w,z}$ each with FFT of \underline{v}_z such that the products are $F(\underline{m}_{w,z}) \cdot F(\underline{v}_z)$ and $F(\underline{r}_{w,z}) \cdot F(\underline{v}_z)$ respectively;

(j) performing an L-point inverse on the results in step (i) such that $F^{-1}(F(\underline{m}_{w,z}) \cdot F(\underline{v}_z))$ and $F^{-1}(F(\underline{r}_{w,z}) \cdot F(\underline{v}_z))$ respectively; and

(k) dividing, element-to-element, the results in step (j) and denoting the result as \underline{H} such that $\underline{H} = \frac{F^{-1}(F(\underline{r}_{w,z}) \cdot F(\underline{v}_z))}{F^{-1}(F(\underline{m}_{w,z}) \cdot F(\underline{v}_z))}$ wherein only the first P elements of sequence \underline{H} are computed and used.

24. The method of claim 23 wherein $F(\underline{H}^*)$ is computed by extended FFT and the result is conjugated and scaled, the method further comprising:

(l) conjugating the sequence \underline{H} ;

(m) multiplying, element-to-element, the conjugate sequence \underline{H}^* by the chirp waveform and denoting the result as \underline{H}_w^* ;

(n) zero padding the conjugate sequences \underline{H}_w^* in the tail until the length of the sequence achieves L, and denoting the resulting sequence as $\underline{H}_{w,z}^*$;

(o) performing an L-point FFT on $\underline{H}_{w,z}^*$;

(p) multiplying, element-to-element, the FFT of $\underline{H}_{w,z}^*$ by FFT of zero-padded chirp sequence \underline{v}_z such that the product is $F(\underline{H}_{w,z}^*) \cdot F(\underline{v}_z)$;

(q) performing L-point inverse FFT on $F(\underline{H}_{w,z}^*) \cdot F(\underline{v}_z)$;

(r) multiplying, element-to-element, the sequence $F^{-1}(F(\underline{H}_{w,z}^*) \cdot F(\underline{v}_z))$ by the chirp waveform;

(s) conjugating the result in step (r); and

(t) scaling the result in step (s) by factor $\frac{1}{P}$ to obtain the estimated channel response.

25. The method of claim 21 wherein the FFT is extended to a proper length L to process a plurality of different burst types by using a chirp transform algorithm (CTA) to compute $F(\underline{r})$ and $F(\underline{m})$.

26. A wireless communication system for performing channel estimation, the system comprising:

(a) means for receiving a time domain signal \underline{r} ;

(b) means for expressing $\underline{r} = \underline{m} \otimes \underline{h}$ in the frequency domain, resulting in an output signal $\underline{R} = \underline{M} \cdot \underline{H}$, where \underline{m} is a midamble sequence, \underline{h} is a channel impulse response, \otimes is a circular convolution operator, \underline{R} is the fast Fourier transform (FFT) of time domain signal \underline{r} , \underline{M} is the FFT of midamble sequence \underline{m} , and \underline{H} is the FFT of channel impulse response \underline{h} , and $\underline{R} = F(\underline{r})$, $\underline{M} = F(\underline{m})$ and $\underline{H} = F(\underline{h})$ where $F()$ is defined as the operator of forward or inverse FFT;

(c) means for calculating \underline{H} is calculated by dividing \underline{R} by \underline{M} , where $\underline{R}/\underline{M}$ is the element-to-element division of the corresponding two FFT sequences; and

(d) means for estimating the impulse response by inverse FFT of \underline{H} by calculating $\underline{h} = F^{-1}(\underline{H})$ where $F^{-1}()$ is defined as the operator of forward or inverse FFT and $\underline{h} = F^{-1}(F(\underline{r})/F(\underline{m}))$ and $F(\underline{r})/F(\underline{m})$ denotes the element-to-element division of FFT sequences $F(\underline{r})$ and $F(\underline{m})$.

27. The system of claim 26 wherein the forward or inverse FFT are exchangeable in the following form: $F^{-1}(\underline{x}) = \frac{1}{P} (F(\underline{x}^*))^*$, wherein P is the length of FFT.

28. The system of claim 27 wherein the FFT sequences $F(\underline{r})$ and $F(\underline{m})$ are calculated by extended FFT and divided element-to-element, the method further comprising:

(e) means for multiplying, element-to-element, the sequences \underline{m} and \underline{r} by a chirp waveform and denoting the resulting sequences as \underline{m}_w and \underline{r}_w respectively;

(f) means for creating a chirp sequence based on the chirp waveform;

(g) means for zero padding the sequences \underline{m}_w , \underline{r}_w and \underline{v} in the tail until the length of the sequences achieves L, and denoting the resulting sequences as $\underline{m}_{w,z}$, $\underline{r}_{w,z}$ and \underline{v}_z ;

(h) means for performing L-point FFT on $\underline{m}_{w,z}$, $\underline{r}_{w,z}$ and \underline{v}_z each such that $F(\underline{m}_{w,z})$, $F(\underline{r}_{w,z})$ and $F(\underline{v}_z)$;

(i) means for multiplying, element-to-element, the FFT of $\underline{m}_{w,z}$ and $\underline{r}_{w,z}$ each with FFT of \underline{v}_z such that the products are $F(\underline{m}_{w,z}) \cdot F(\underline{v}_z)$ and $F(\underline{r}_{w,z}) \cdot F(\underline{v}_z)$ respectively;

(j) means for performing an L-point inverse on $F(\underline{m}_{w,z}) \cdot F(\underline{v}_z)$ and $F(\underline{r}_{w,z}) \cdot F(\underline{v}_z)$ such that $F^{-1}(F(\underline{m}_{w,z}) \cdot F(\underline{v}_z))$ and $F^{-1}(F(\underline{r}_{w,z}) \cdot F(\underline{v}_z))$ respectively; and

(k) means for dividing, element-to-element, $F^{-1}(F(\underline{m}_{w,z}) \cdot F(\underline{v}_z))$ by $F^{-1}(F(\underline{r}_{w,z}) \cdot F(\underline{v}_z))$ and denoting the result as \underline{H} such that $\underline{H} = \frac{F^{-1}(F(\underline{r}_{w,z}) \cdot F(\underline{v}_z))}{F^{-1}(F(\underline{m}_{w,z}) \cdot F(\underline{v}_z))}$ wherein only the first P elements of sequence \underline{H} are computed and used.

29. The system of claim 28 wherein $F(\underline{H}^*)$ is computed by extended FFT and the result is conjugated and scaled, the system further comprising:

- (l) means for conjugating the sequence \underline{H} ;
- (m) means for multiplying, element-to-element, the conjugate sequence \underline{H}^* by the chirp waveform and denoting the result as \underline{H}_w^* ;
- (n) means for zero padding the conjugate sequences \underline{H}_w^* in the tail until the length of the sequence achieves L, and denoting the resulting sequence as $\underline{H}_{w,z}^*$;
- (o) means for performing L-point FFT on $\underline{H}_{w,z}^*$;
- (p) means for multiplying, element-to-element, the FFT of $\underline{H}_{w,z}^*$ by FFT of zero-padded chirp sequence \underline{v}_z such that the product is $F(\underline{H}_{w,z}^*) \cdot F(\underline{v}_z)$;
- (q) means for performing an L-point inverse FFT on $F(\underline{H}_{w,z}^*) \cdot F(\underline{v}_z)$;
- (r) means for multiplying, element-to-element, the sequence $F^{-1}(F(\underline{H}_{w,z}^*) \cdot F(\underline{v}_z))$ by the chirp waveform;
- (s) means for conjugating the output of means (r); and
- (t) means for scaling the output of means (s) by factor $\frac{1}{P}$ to obtain the estimated channel response.

30. The system of claim 25 wherein the FFT is extended to a proper length L to process a plurality of different burst types by using a chirp transform algorithm (CTA) to compute $F(\underline{r})$ and $F(\underline{m})$.